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THE FEEDING of DAIRY COWS

IF DAIRY COWS are to be fed for profitable production they must receive a liberal ration at all seasons. In summer, pasture generally is depended upon, but often it must be supplemented by soiling crops or silage, and sometimes by concentrates as well. For winter feeding, the ration usually is composed of hay, silage, and a mixture of grains. In properly balancing the ration the grain mixture is compounded to fit the roughage with due consideration for cost, bulk, palatability, and physiological effect upon the cow. For best results, cows must be fed individually, salted regularly, and furnished with all the clean water they will drink.

A few simple guides for feeding may be summarized as follows:

1. Under most circumstances the cow should be fed all the roughage that she will eat up clean, and the grain ration should be adjusted to the milk production.

2. A grain mixture should be fed in the proportion of 1 pound to each 3 pints or pounds of milk produced daily by the cow, except in the case of a cow producing a flow of 40 pounds or more, when the ration may be 1 pound to each 3½ or 4 pounds of milk. An even better rule is 1 pound of grain each day for every pound of butterfat that the cow produces during the week.

3. Feed all the cow will respond to in milk production. When she begins to put on flesh, cut down the grain.

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THE FEEDING OF DAIRY COWS.[1]

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SUCCESSFUL feeding of dairy cows from an economic standpoint involves the providing of an abundant supply of palatable, nutritious feed, at the minimum cost per unit of feed, and supplying it to the cow in such way as to secure the largest production for feed consumed. This bulletin gives some factors involved in the economical selection of feeds and to guide the producer in supplying them to the cows.

LIBERAL FEEDING NECESSARY FOR PROFIT.

The dairy cow has been likened by many writers to a machine or a manufacturing plant. This comparison can be applied literally, with certain reservations. A certain proportion of the power furnished any machine is used for running the machine itself and is not in any sense productive. In a steam engine this is represented in the exhaust steam, in heat which escapes without producing steam, and in the friction of the working parts of the engine. In the manufacturing plant it is represented by the managerial, the clerical, and sales forces. These forces, while necessary for the successful operation of the business, are, in a sense, unproductive.

In the feeding of the dairy cow this overhead expense, this unproductive force, is termed the "maintenance ration," and is that portion of the feed given the cow which is used by her to perform her own functions, such as heating the body, pumping the blood, di-

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gesting the feed, and moving the body from place to place. This feed, from a productive standpoint, is entirely lost to the farmer. The cow can produce without loss of body weight only after she has exacted this toll of maintenance. Having received feed enough to maintain her, practically all the feed she consumes above this can be used for milk production. This maintenance ration is a fixed charge, and the more feed a cow can consume above that required for maintenance the greater the amount available for production.

Feeding for profit can, therefore, be defined as liberal feeding, or feeding to the full capacity of the cow. This point is illustrated by Table 1. (These figures are only approximate but will serve to illustrate the point.)

TABLE 1.—*Approximate proportions of cows' feed required for maintenance and available for milk production.*

Cost of ration.	Cost of maintenance.	Available for milk production.	Proportion of ration available for production.
Cents.	*Cents.*	*Cents.*	
10	10	.....	.....
15	10	5	One-third.
20	10	10	One-half.
25	10	15	Three-fifths.

It will be noted in Table 1 that when the cow is fed only a maintenance ration no feed is available for milk production; when she is fed twice this quantity, half the feed can be used for milk production; when she is fed two and a half times the maintenance, three-fifths of the feed can be so used. One of the most common mistakes in the feeding of dairy cattle on our farms is that the good cows are not fed a sufficient quantity of feed above that required for maintenance. This is especially true of the highly specialized dairy cow; that is, the cow which when fed all she will take makes it all into milk, except what is needed for maintenance. It is, however, unfortunately true that all cows in the dairies of the country are not this kind. Some cows when fresh make all the feed above maintenance into milk for a period of several months before they begin to lay on flesh; others, if fed heavily, begin to gain in weight soon after freshening. From the standpoint of economical milk production one can not generally afford to give a dairy cow more than she will consume without gaining in weight. There are times, however, when it is desirable to make exceptions to this rule; for example, practically all highly specialized milk producers in the early part of the lactation period lose in weight; that is, they produce milk at the expense of

their own body flesh. When such cows approach the end of their milking period they normally regain the flesh they have lost in the early part of this period. The feeder can, therefore, well afford to feed such cows liberally, being assured that the feed will be returned to him in the form of milk when the cows again freshen.

SUMMER FEEDING.

The problems involved in winter and summer feeding are so different as to make a natural division between the two. Summer feeding ordinarily consists in the use of pastures or soiling crops. These may be supplemented when necessary by silage or other roughage or by grain. When dry feeds alone are fed in the summer, the problems are not materially different from winter feeding.

PASTURE.

Pasture is the natural feed for dairy cows, and in many respects the best. With abundance of good grasses in fresh, succulent condition, we have one of the rations most conducive to heavy production. Even with the very best of pasture, however, a cow can not be forced to maximum production on it alone. This is owing to the fact that for the greatest production she must be induced to take a large amount of nutrients. The bulky nature of pasture grass places a positive limit upon the capacity of the cow to take feed. In other words, the cow's stomach can not contain grass enough to supply the required nutrients for maximum milk production; therefore, a part of the ration should be of a more concentrated nature. Good pasture contains an abundant supply of succulent, palatable, and nutritious grasses. On such pasture it should be possible for a cow to satisfy her appetite with a few hours' grazing. Pasture of this kind will supply all the food material needed for medium production and a large part of that necessary for large production. For average conditions, with ample pasture of good grasses or legumes in good, succulent condition, good production can be secured. The economy of the use of pasture depends chiefly upon several factors, such as the price of land, the price of labor, and the lay of the land.

PRICE OF LAND.

The price of land has a direct bearing upon the cost of pasture and is an important factor where land values are high. If pasture is to be depended upon entirely for from four to six months in the year, and production is to be kept up to a profitable standard, anywhere from 1 to 4 acres or more must be provided for each cow. This is assuming that in permanent pasture there is a good, clean turf, with

little or no waste places, and that for temporary pasture there is a good stand of grass or legumes throughout. Land which will give these conditions frequently sells at from $50 to $300 an acre, and the interest on the investment must necessarily also vary widely, as is shown in Tables 2 and 3:

TABLE 2.—*Interest on cost of pasture per cow for the season; interest at 6 per cent on the value of the land, allowing from 1 to 4 acres per cow.*

Acres per cow.	Value of land per acre.				
	$25	$50	$100	$150	$200
1	$1.50	$3.00	$6.00	$9.00	$12.00
1½	2.25	4.50	9.00	13.50	18.00
2	3.00	6.00	12.00	18.00	24.00
2½	3.75	7.50	15.00	22.50	30.00
3	4.50	9.00	18.00	27.00	36.00
3½	5.25	10.50	21.00	31.50	42.00
4	6.00	12.00	24.00	36.00	48.00

TABLE 3.—*Cost of pasture per cow per day on basis of Table 2, with a pasture season of 150 days.*

Acres. per cow.	Value of land per acre.				
	$25	$50	$100	$150	$200
	Cents.	*Cents.*	*Cents.*	*Cents.*	*Cents.*
1	1	2	4	6	8
1½	1½	3	6	9	12
2	2	4	8	12	16
2½	2½	5	10	15	20
3	3	6	12	18	24
3½	3½	7	14	21	28
4	4	8	16	24	32

It will be seen that the price of land may readily become so high that it would be unprofitable to graze it. In many sections of the country a cow can be fed on dry feed for average production for about 20 cents a day. Therefore, when the daily rental or interest on the value of pasture approaches that sum the farmer should carefully consider other methods of summer feeding.

The cost of caring for permanent pastures must also be taken into consideration. This will consist in the expense of cutting weeds, building and repairing fences, etc.

PRICE OF LABOR.

The pasture system of summer feeding reduces to the minimum the amount of labor required to handle a given number of cows, and, therefore, it is especially adapted to conditions where labor is high.

LAY OF LAND AND ROUGHNESS OF SURFACE.

In mountainous or hilly sections of the country there is often a part of the farm which, on account of steepness, tendency to wash, or the presence of rock formation near the surface, can not or should not be plowed frequently. On such farms it is often best to plow only the bottoms, keeping the uplands in permanent pastures. The dairyman will find ready application of the pasture system for summer feeding on such farms.

PASTURE WITH SUPPLEMENTS.

GRAIN.

As has been said, the supplementing of pastures with grain is sometimes advisable, even when the pastures are of the best. In many sections, however, pastures are never of the best kind, and in no sections are they always in the best condition. It is evident, therefore, that the commercial dairyman will seldom depend upon pasture alone. Grain should be fed to heavy-producing cows under all pasture conditions.

Prof. C. H. Eckles, of the University of Missouri, suggests the following-named quantities of grain with abundant pasture for varying production:

Jersey cow producing—	
20 pounds of milk daily	3 pounds of grain.
25 pounds of milk daily	4 pounds of grain.
30 pounds of milk daily	6 pounds of grain.
35 pounds of milk daily	8 pounds of grain.
40 pounds of milk daily	10 pounds of grain.
Holstein-Friesian or Ayrshire cow producing—	
25 pounds of milk daily	3 pounds of grain.
30 pounds of milk daily	5 pounds of grain.
35 pounds of milk daily	7 pounds of grain.
40 pounds of milk daily	9 pounds of grain.
50 pounds of milk daily	10 pounds of grain.

While this is, of course, an arbitrary rule and variations should be made to suit different conditions and individual cows, it is in accord with good feeding practice and probably is as good a rule of its kind as has been formulated.

For cows of medium production it is usually more economical to feed silage or some green crop rather than grain for supplementing short pasturage. In supplementing pasture with grain it should be remembered that the percentage of protein in the grain ration need not be the same as for winter feeding. Good pasture is an approximately balanced ration. The grain ration to be fed with pasture grass should, therefore, have approximately the same proportion of protein to other nutrients. In the case of extra-heavy pro-

ducers the percentage of protein in the grain mixture should be somewhat greater.

The following-named mixtures are suggested for supplementing pasture without other roughage:

Mixture No. 1:		
Ground oats	100 pounds	Per cent digestible protein, 10.3.
Wheat bran	100 pounds	
Corn meal	50 pounds	
Mixture No. 2:		
Wheat bran	100 pounds	Per cent digestible protein, 12.7.
Corn meal	100 pounds	
Cottonseed meal	25 pounds	
Mixture No. 3:		
Corn-and-cob meal	250 pounds	Per cent digestible protein, 15.5.
Cottonseed meal	100 pounds	
Mixture No. 4:		
Wheat bran	100 pounds	Per cent digestible protein, 13.6.
Gluten feed	50 pounds	
Corn meal	50 pounds	

SOILING CROPS.

Pastures, except where irrigation is practiced, are so dependent upon rainfall that there is practically sure to be some period each season when they are short. It is a well-known fact among dairymen that if a cow, for lack of proper feed, falls off in her flow of milk for any period of time it is difficult or impossible to bring her back to a full flow until she again freshens. To carry the cows over this period on grain alone is expensive; consequently, the supplementing of pasture with soiling crops is becoming much more common and is growing in favor. In fact, in many sections it is extremely difficult to keep a herd in maximum production throughout the summer without furnishing some supplemental feed. Unless an abundance of pasture is available, there is practically sure to be a shortage toward the end of the season. Special crops can be grown for these shortages, but they usually involve added expense and inconvenience compared with standard farm crops. Second-growth red clover, oats, peas, or alfalfa are excellent. Corn is available in August and September. These crops are usually a part of the regular cropping system of a well-conducted dairy farm.

The advantages of soiling crops as a supplement to pasture are that large quantities of forage can be grown on a relatively small area, because it is frequently possible to harvest more than one crop in a season on land used for soiling. Another advantage is the palatability and succulence possessed by such crops. With their use pasture need not be cropped so closely and less feed is wasted through tramping by the cattle. By judicious application of the soiling sys-

tem it is often possible to reduce the acreage of land used for pasture, which in addition to the saving in land required for pasture has the added saving in the cost of fencing. Soiling crops usually are fed in the stable where the manure can be saved for application on cultivated fields.

An objection which can be urged against the use of soiling crops is the greater amount of labor required and the difficulty in using this labor to the best advantage. Another difficulty is to plan a succession of special crops which will at all times during the season supply an abundant supplementary feed. Even with the best arranged plan, its success depends very largely upon weather conditions.

THE SUMMER SILO.[1]

Silage has found a wide use in this country as a palatable, succulent, and economical roughage for use during the winter. Many of the advantages of its use in winter apply equally well in summer, and there are additional ones that apply alone to the latter season.

The use of a summer silo is particularly applicable on high-priced land. If the land is pastured it will require from 1 to 3 or more acres a season for each cow, while 1 acre of corn put in the silo will supply succulent roughage for several cows for a like period. It is true that grain will be necessary in addition to silage, but the great problem on high-priced land is to raise a sufficient quantity of roughage.

As has previously been said, soiling crops have been used to a great extent either in place of or in addition to pasture. The greatest disadvantage in their use is that much labor is required. In order to use these crops they must be cut and hauled from day to day. This work is expensive because only small areas are cut at one time, thus making it impracticable to use the harvesting machinery of the farm to advantage and entailing considerable loss of time in harnessing and unhitching the team. Considerable inconvenience also is occasioned by the fact that the field work is pressing at that season of the year and both man and horsepower are badly needed in the fields. Silage, on the other hand, is cut at one operation when the work in the field is not pressing. The crop ordinarily grown for silage is corn, which is a part of the regular farm rotation and consequently fits in well with the regular routine of work.

With a silo for summer feeding, the dairyman always has an abundant supply of feed that is easily handled. By using silage the necessity of cutting and hauling the supplementary roughage during rainy weather is eliminated. Another advantage as compared with

[1] See Farmers' Bulletin No. 578, "The Making and Feeding of Silage."

the soiling system lies in the fact that with the latter it is often necessary to feed a portion of each crop after it has matured too much to be palatable, and probably to start on the succeeding one while it is still a little too green. It is difficult to plan exactly so as to prevent these conditions. With silage, however, the crop can be cut at the best stage for feeding and preserved at that point.

One of the most important uses of silage in the summer is as a supplement for short or poor pasture. This condition frequently occurs as a result of long-continued dry weather. Under such circumstances even the most carefully planned soiling system may fail. It is then that the greatest value of the summer silo is realized, for with the silo full of well-matured silage grown in the previous season, an abundant supply of succulent feed for the cows is available, regardless of weather conditions.

When it is not necessary to use the silo during the summer, it can be sealed up and the silage preserved for winter use. This prevents any waste in feed.

One point, however, must be kept in mind in planning the summer silo.[1] This is the diameter of the silo in relation to the number of cows to be fed and the quantity to be fed to each cow. Silage enough must be fed daily to prevent excessive surface fermentation. As a general rule, a cow under summer conditions will consume about 20 pounds a day. On this basis the diameter of the silo in reference to the number of cows to be fed in summer will be as follows:

20 cows	8 feet in diameter.
30 cows	10 feet in diameter.
40 cows	12 feet in diameter.

Inasmuch as 8 feet is about the minimum diameter of a silo in best practice, it will be seen that the summer silo for supplementing pasture has its best application in herds of 20 cows or more.

WINTER FEEDING.

The problems involved in winter feeding are usually distinctly different from those of summer feeding. Pasture (or green feed), usually the basis of summer feeding, is not available. Broadly speaking, there are two factors involved in this problem, first, to satisfy the needs of the cow and, second, to suit the pocketbook. The cow must have an ample supply of feed of a palatable nature, and this feed must be supplied at a price which will permit a profit on the feeding operation.

Viewed from an economic standpoint, there are some fundamental considerations which should first receive attention. In general farm practice it is advisable, so far as is economical, to use the feeds pro-

[1] See Farmers' Bulletin No. 589, "Homemade Silos."

duced on the farm. Often the freight rates and the middleman's charges, if saved, will constitute a good profit for the feeder. This is especially true of roughage. Such feeds are bulky and in most cases must be baled at a considerable cost; the freight rates also are much greater in proportion to the nutrients contained than on the grains.

When land is high in price and the markets for dairy products are good, it is often impracticable to grow all the feeds on the farm. In such cases arrangements first should be made to grow the roughage, on account of the high cost of transporting these feeds. In most cases the prime object of the farm under such conditions will be to supply the greatest possible quantity of roughage.

It is a difficult problem to provide a system of winter feeding of roughage which will make the best use of home-grown roughage and at the same time insure full production. Only a general discussion of the problem can be attempted.

SILAGE.

In addition to containing the proper nutrients in the right proportion, part of the ration should be of a succulent nature. It is extremely difficult, if not impossible, to keep cows in full production throughout the winter without some succulent feed. There are two chief sources of succulent feed for winter feeding—silage and roots. Of these, silage is in almost universal use by commercial dairymen. While almost any green crop may be used for silage, the heavy yields of corn, as compared with other crops, and its comparative ease of handling, together with its keeping qualities, make it the leading silage crop. Where the cost of land and the prices of dairy products are high, and the system of farming of necessity is intensive, it is questionable whether the dairyman should consider any other silage crop.

ROOTS.

The chief function of roots in cattle feeding is to supply a succulent feed. Under general farm conditions the quantity of nutrients grown per acre in root crops is small in comparison to the cost of production. These root crops, however, can be preserved during the winter equally well whether large or small quantities are fed each day, and therefore have special application when only a few cows are to be fed. Of the different root crops, mangel-wurzels furnish the greatest yield per acre. Other kinds of beets and turnips and carrots may be used. Turnips, however, should be fed after milking rather than before, as they cause a bad flavor in the products if fed immediately before milking. Carrots impart a desirable color to the milk.

DRY ROUGHAGE.

The best kinds of dry roughage to be fed to the dairy cow, in connection with corn silage or roots, are leguminous hays, such as alfalfa, red, crimson, or alsike clover and soy-bean or cowpea hay. While corn silage is an excellent feed, it is not a balanced one, as it does not contain sufficient protein and mineral matter to meet fully the requirements of the cow. The leguminous hays, in addition to being very palatable, have a tendency to correct this deficiency. They are also one of the best and cheapest sources of protein. One or more of these hays can be grown on any farm, and in addition to their value for feeding purposes, they improve the soil in which they are grown. Hay from Canada field peas, sown with oats to prevent the peas from lodging, also makes an excellent roughage.

Corn stover, coarse hay, etc., also find a good market through the dairy cow. This class of roughage is low in protein, however, and when it is used the grain ration must be richer in protein.

No positive rule can be laid down as to the quantity of dry roughage that should be fed, but about 6 to 12 pounds a day for each cow, in addition to silage, will be found to be satisfactory in most cases. When the dry roughage is of poor quality, such as coarse, weedy hay or a poor grade of cornstalks, a large portion can often be given to advantage, allowing the cow to pick out the best and using the rejected part for bedding. With this quantity of dry roughage the cow will take, according to her size, from 25 to 50 pounds of silage. This may be considered as a guide for feeding to apply when the roughage is grown on the farm. When everything has to be purchased, it is often more economical to limit the quantity of roughage fed and increase the grain ration.

ROUGHAGE ALONE TOO BULKY A RATION.

While a cow's stomach is large and her whole digestive system is especially designed to utilize coarse feeds, there is a limit to the bulk that she can take. This limit is below the quantity of roughage that it would require to furnish the nutrients she must have for maximum production; that is, a ration may contain the proper proportions of protein and carbohydrates and still be so bulky that she can not handle it. She therefore should have some grain even though the roughage in itself is a balanced ration.

IMPORTANCE OF A BALANCED RATION.

It is probably well at this point to refer briefly to the composition of feedstuffs as it relates to economical feeding of the dairy cow. The cow takes into her digestive system feeds which she utilizes for

the production of body tissues, heating the body, performing bodily functions, such as digesting feed, moving from place to place, and for milk production. For the purposes of the present discussion, it is sufficient to say that the constituents or compounds and the relative quantities necessary for these operations have been determined; that is, we know that milk contains protein and energy or heat-producing constituents, the protein being represented by the casein and albumin and the energy and heat-producing constituents by the fat and sugar. In addition to the constituents or compounds necessary for the production of milk, she also must have the constituents necessary for performing the other functions mentioned. These, for convenience, have been classified into proteins, carbohydrates, and fats. Fats perform much the same functions as carbohydrates and are worth for production practically two and one-fourth times as much per pound as carbohydrates, and in the balancing of a ration are usually classed with them. This brings us to a definition of a "balanced ration," which is a ration containing these various nutrients in the proportion the cow needs them.

The economical importance of a balanced ration is evident. The cow can use only certain elements or compounds in certain proportions; consequently, if the ration supplies an excessive amount of any one, the excess is liable to be wasted. Not only is this true, but as the cow has to assimilate it even though she can not use it, her capacity for production is reduced.

COST.

In making a ration, cost is one of the important factors. The best practice is to compound a grain mixture so that it will balance with the home-grown roughage. With this in mind, the separate grains should be selected to supply the necessary nutrients at the lowest possible cost. For this, not only the price per hundred pounds but also the relative cost of each constituent, especially protein, must be considered. For example, to determine the cost of a pound of digestible protein in a given feed divide the price of 100 pounds by the per cent of digestible protein in the feed. If this calculation is made for several feeds, the relative cost of protein in each will be apparent. Then the feeds that furnish protein at the least cost can be selected. The same can be done to determine the cost of the carbohydrates and fat, which are the heat-making or energy-producing part of the feed.

BULK.

A certain bulk is necessary in the grain mixture to obtain the best results. When heavy feeds are used, some bulky ones should be included to lighten the mixture, since it is probable that a certain degree

of bulkiness aids digestion. Some of the common feeds are classified as to bulk in Table 4:

TABLE 4.—*Classification of common feeds as to bulkiness.*

Bulky.	Medium.	Heavy or compact.
Alfalfa meal.	Corn meal or feed.	Cottonseed meal.
Corn-and-cob meal.	Hominy.	Linseed meal.
Bran (wheat).	Gluten feed.	Coconut meal.
Dried brewers' grains.	Rye.	Peanut meal.
Dried distillers' grains.	Barley.	Gluten meal.
Oats, ground.	Buckwheat middlings.	Wheat middlings.
Malt sprouts.		
Dried beet pulp.		

PALATABILITY.

Palatability is of great importance in successful feeding. The best results can not be obtained with any feed which is not well relished by the cow; consequently any unpalatable feed to be used should be mixed with those that are appetizing.

PHYSIOLOGICAL EFFECT.

In making the grain mixture care should be exercised that too large a quantity of either constipating or laxative feed is not included. Cottonseed meal, for example, is decidedly constipating and should be fed with laxative grains or succulence, such as silage or roots. For ordinary feeding in most parts of the United States not more than one-third of the grain should be cottonseed meal. In some sections larger quantities have been fed, but this practice is not to be recommended. On the other hand, linseed-oil meal, because of its distinctly laxative action, should not be fed ordinarily in greater quantities than 1½ pounds a day.

NUTRITIVE VALUE OF THE GRAINS AND CONCENTRATES.

As a general rule, the energy or heat-producing material is found chiefly in the stem and leaves of the plant and the protein is largely in the seeds. The great exception is in the case of legumes, which have larger percentages of protein throughout the plant and particularly in the leaves. It should be noted, therefore, that in supplying grain we are chiefly concerned with the protein it contains.

Two classes of feeds are used for making up the grain ration, namely, grains and by-products of the manufacturing industries. The grains produced on the farm and commonly used for cattle feeding are corn, oats, barley, and rye. In many cases the demand for these grains for other purposes has become so great that the dairyman can not afford to use them; consequently, it has usually been found more economical to use the by-products of the manufacturing

industries. The following are among the most common of these feeds: Wheat bran, wheat middlings, linseed meal, cottonseed meal, gluten meal, gluten feed, hominy feed, brewers' grains, malt sprouts, distillers' grains, beet pulp, molasses, buckwheat middlings, coconut meal, peanut meal.

The following analyses[1] represent digestible nutrients in 100 pounds. The fat is multiplied by 2.25 and added to the carbohydrates. This represents the energy or heat-making part of the feed.

WHEAT BRAN.

Digestible nutrients.—Protein, 12.5 per cent; carbohydrates and fat, 48.4 per cent.

Bran is the outside coating of grains, and is the residue or by-product from the manufacture of flour. Wheat bran may be derived from winter or spring wheat, and there is little difference in its composition from either source.

From a physiological standpoint wheat bran is one of the very best feeds for cows. It is slightly laxative in nature, and generally tends to keep the cow's digestive system in good condition. The price based upon its protein content is usually so high that most commercial dairymen combine it with other feeds in which protein costs less per pound. Aside from the value of the nutrients which it contains, it has a special value in a feeding mixture, as it gives bulk and adds to the palatability. Wheat bran may be used when the rest of the grain ration is lacking in palatability or is of a constipating nature. It is especially good when the roughage is all dry. The best grades of wheat bran are of light weight, with large flakes. Some of the large mills put the sweepings from the mill into the bran; therefore, it is usually best to buy the highest grade of bran, provided the mills grading it are reliable. The output of small country mills is usually of excellent quality. Bran contains a high proportion of phosphorus and potash in its ash content.

WHEAT MIDDLINGS.

Digestible nutrients.—Protein, 13.4 per cent; carbohydrates and fat, 55.9 per cent.

Standard wheat middlings or shorts are composed of the finer portions of the bran together with the coarser portion of the flour. They are not quite so flaky as bran, are a little less laxative, and contain a somewhat smaller quantity of ash. In other respects they may be said to resemble bran closely. This feed is somewhat pasty when moist, and consequently lacks bulk.

[1] The analyses of digestible protein, carbohydrates, and fat of the various feeds are taken from "Feeds and Feeding," by Henry and Morrison.

LINSEED MEAL.

Digestible nutrients.—Old process: Protein, 30.2 per cent; carbohydrates and fat, 47.7 per cent. New process: Protein, 31.7 per cent; carbohydrates and fat, 44.2 per cent.

Linseed meal is a by-product of the manufacture of linseed oil from flaxseed, and is produced under two processes, known as the old and the new. Linseed meal or oil meal from a physiological standpoint is one of the very best feeds. It is laxative, palatable, and a very good "conditioner," but, like wheat bran, its price is usually excessive for its nutritive value. It has, however, a distinct place in a mixture in supplying protein to increase the palatability and improve the physiological effect. It is very heavy, so that it is well to feed it in connection with a bulky feed. It is especially applicable in a mixture to be fed with dry roughage.

COTTONSEED MEAL (CHOICE).

Digestible nutrients.—Protein, 37 per cent; carbohydrates and fat, 41.2 per cent.

Cottonseed meal is the richest in protein of all the common cow feeds on the market. It is usually the cheapest source of protein available, but it does not have the best physiological effect upon the cow, often causing digestive troubles if fed in large quantities for long periods. At first it is advisable to start with 1 to 2 pounds a day, gradually increasing the quantity if no bad results are observed. In some herds in the North as high as 5 to 6 pounds a day are fed without bad results. In the South there seems to be no limit in this direction.

Cottonseed meal is a highly concentrated feed and should, if possible, be fed in a mixture with some bulky feed like bran. It can be fed to better advantage when the roughage contains an ample quantity of succulent feed. While its physiological effect in the North at least is not good as compared with most other cow feeds, its cheapness and the fact that in time the cows seem to overcome this tendency to digestive trouble from it are rapidly giving it great prominence as a cheap source of protein for dairy cows.

GLUTEN MEAL AND GLUTEN FEED.

Digestible nutrients.—Gluten meal: Protein, 30.2 per cent; carbohydrates and fat, 53.8 per cent. Gluten feed: Protein, 21.6 per cent; carbohydrates and fat, 59.1 per cent.

Gluten meal is a by-product of the manufacture of starch from corn. The basis of the meal is the germ part of the corn kernel. Gluten feed is composed of the gluten meal plus a certain quantity of corn bran, which makes it lighter than the meal. Both feeds are fairly palatable and are usually among the cheapest sources of protein.

DRIED BREWERS' GRAINS.

Digestible nutrients.—Protein, 21.5 per cent; carbohydrates and fat, 44.2 per cent.

Dried brewers' grains rank with wheat bran as a flaky, bulky feed. The physiological effect is nearly if not quite as good as bran. They differ in that they carry a somewhat larger percentage of protein than bran. Cows sometimes do not eat these grains readily at first, but soon overcome this aversion.

MALT SPROUTS.

Digestible nutrients.—Protein, 20.3 per cent; carbohydrates and fat, 50.3 per cent.

Malt sprouts are loose and bulky and cows usually do not take them readily at first. The chief place of this feed is with other feeds in a mixture. Both brewers' grains and malt sprouts come from barley and are by-products from the manufacture of beer.

The proprietary feed companies control at the present time a large percentage of the output of dried grains and malt sprouts from the larger breweries and these excellent feeds do not now appear unmixed on the market to so great an extent as they did a few years ago.

HOMINY MEAL, FEED, OR CHOP.

Digestible nutrients.—Protein, 7 per cent; carbohydrates and fat, 77.6 per cent.

This by-product of the manufacture of hominy consists of part of the starchy portion of the corn and part of the germ. It is variously known, as the heading suggests, as hominy meal, feed, or chop. In many respects it resembles corn and is a good substitute for it. This feed is used chiefly to furnish the energy or heat-making part of the ration, but because of its low percentage of protein it is not an economical source of the latter.

DRIED DISTILLERS' GRAINS.

Digestible nutrients.—Corn grains: Protein, 22.4 per cent; carbohydrates and fat, 66.5 per cent. Rye grains: Protein, 13.6 per cent; carbohydrates and fat, 52.8 per cent.

These grains are the by-product of the manufacture of alcohol and distilled liquors from corn and rye. Both kinds are rather bulky and usually the corn grains are among the cheapest sources of protein. These grains are not particularly palatable, consequently they should be used with other feeds in the grain ration.

DRIED BEET PULP.

Digestible nutrients.—Protein, 4.6 per cent; carbohydrates and fat, 67 per cent.

Dried beet pulp is a by-product from the manufacture of sugar from the beet. As a source of protein it is not of high value, and the

farmer should recognize this fact when he buys it. It is bulky, however, and has an excellent physiological effect upon the cow, as it aids in keeping her digestive organs in good condition. When for any reason neither silage nor roots are available the pulp can be soaked for about 12 hours in about four times its weight of water; it then constitutes a good substitute for a succulent roughage. Beet pulp should be classed as a carbohydrate rather than as a protein feed.

MOLASSES.

Digestible nutrients.—Protein, 1 per cent; carbohydrates and fat, 58.2 per cent.

Molasses, from both the beet and cane sugar factories, is valuable as a source of energy or heat-making material, the main difference between the two kinds being that the former is more laxative when fed in large quantities. When fed in small quantities, molasses adds materially to the palatability of the ration, but unless it is very low in price it is not usually an economical feed for dairy cows.

BUCKWHEAT MIDDLINGS.

Digestible nutrients.—Protein, 24.6 per cent; carbohydrates and fat, 52 per cent.

This floury feed is composed largely of that part of the buckwheat kernel under the hull together with some of the coarsest of the flour. It is rather heavy and tends to produce a tallowy butter if fed in large quantities. In certain sections it is one of the cheap sources of protein. Frequently bran and chaff are added to the middlings, thus greatly reducing their feeding value.

COCONUT MEAL.

Digestible nutrients.—Protein, 18.8 per cent; carbohydrates and fat, 60.2 per cent.

This meal is the ground cake resulting from the manufacture of coconut oil. It is a rather heavy feed which, on account of its high oil content, tends to become rancid if kept for long periods in the summer. If it is possible to obtain coconut meal at a reasonable price it will be found to be a valuable addition to the ration.

PEANUT MEAL.

Digestible nutrients.—Hulled nuts: Protein, 42.8 per cent; carbohydrates and fat, 36.6 per cent. With hulls: Protein, 20.2 per cent; carbohydrates and fat, 38.5 per cent.

This meal is the by-product of the manufacture of peanut oil and varies greatly in composition, depending upon the percentage of hulls it contains. It is an excellent dairy feed and in some sections is a cheap source of protein.

FARM GRAINS.

Some of the more common grains that are grown upon the farm will be described briefly below.

CORN.

Digestible nutrients.—Corn meal: Protein, 6.9 per cent; carbohydrates and fat, 76.9 per cent. Corn-and-cob meal: Protein, 6.1 per cent; carbohydrates and fat, 72 per cent.

Corn is probably the most common grain grown upon the farm and is well adapted to be part of the ration of a dairy cow. Corn is palatable, heavy, and one of the best and cheapest sources of the energy or heat-making part of the ration, but, on account of its low protein content, it should not form the entire grain ration. In order to lighten up this grain, the cob is often ground with the kernel, the resulting meal being called corn-and-cob meal. This feed is more bulky and better adapted for mixing with heavy grains.

OATS (GROUND).

Digestible nutrients.—Protein, 9.4 per cent; carbohydrates and fat, 60.6 per cent.

This very palatable cereal is slightly laxative and very well adapted for feeding dairy cattle. Owing to the high market price of oats, it is usually more economical to sell them and purchase other feeds which furnish nutrients at a cheaper price.

BARLEY (GROUND).

Digestible nutrients.—Protein, 9 per cent; carbohydrates and fat, 70.4 per cent.

This is a palatable feed and one that can be used to good advantage as a source of carbohydrates or energy material for dairy cows where its price is moderate. Like corn, it should not be the only grain in the ration.

RYE (GROUND).

Digestible nutrients.—Protein, 9.2 per cent; carbohydrates and fat, 70.5 per cent.

This grain is not especially palatable and should not be used in large quantities, as it tends to produce a hard, tallowy butter. Mixed with other feeds, it is often a valuable addition to the ration.

ROUGHAGE.

All roughage may be divided for convenience into two general classes with reference to its content of protein. In the first, or low-protein, class are placed corn silage, corn stover, timothy hay, millet

hay, prairie hay, hays from the common grasses, straws of the various cereals, and cottonseed hulls. The second, or high-protein, class includes the various legume hays, such as alfalfa, the clovers, cowpea, soy bean, and oat and pea. Economy in feeding demands that grain should supplement the roughage, consequently the grain mixtures will be compounded to fit the class to which the roughage belongs.

COMPOUNDING A GRAIN MIXTURE.

A few simple rules for making up a grain mixture are given briefly below:

1. Make up the mixture to fit the roughage available. With roughage entirely of the low-protein class the grain should contain approximately from 18 to 22 per cent of protein, while with exclusively high-protein roughage the grain ration need contain only about 13 to 16 per cent.
2. Select grains that will furnish the various constituents, especially protein, at the least cost, using home-grown grains if possible.
3. Be sure that the mixture is light and bulky.
4. The mixture should be palatable.
5. See that the grain has the proper physiological effect upon the cow.

All these suggestions should be kept in mind in order to obtain the best possible combination of grains. For the convenience of the feeder Table 5, showing the digestible protein content of the more common grains and by-products feeds, is given. The per cent columns are arranged in 5 per cent divisions.

TABLE 5.—*Approximate digestible protein content of various grains and by-products.*

Average 5 per cent (2.5 to 7.4 per cent).	Average 10 per cent (7.5 to 12.4 per cent).	Average 15 per cent (12.5 to 17.4 per cent).	Average 20 per cent (17.5 to 22.4 per cent).
Corn meal. Corn-and-cob meal. Hominy feed. Dried beet pulp.	Wheat, ground. Oats, ground. Barley, ground. Rye, ground. Buckwheat, ground. Sorghum grains, ground.	Wheat bran. Wheat middlings. Dried distillers' grains (rye).	Gluten feed. Malt sprouts. Dried brewers' grains. Dried distillers' grains (corn). Coconut meal. Peanut meal with hulls. Cowpeas.
Average 25 per cent (22.5 to 27.4 per cent).	**Average 30 per cent (27.5 to 32.4 per cent).**	**Average 35 per cent (32.5 to 37.4 per cent).**	**Average 40 per cent (37.5 to 42.4 per cent).**
Buckwheat middlings.	Gluten meal. Linseed meal (both processes). Soy beans.	Cottonseed meal.	Peanut meal (hulled nuts).

The per cent of protein in a grain mixture may be found as follows: Take any number of parts of any number of feeds in the table, and for each part put down the per cent of the column in which it is found. Add these numbers and divide the sum by the number of parts. Examples:

1 part wheat bran		15
1 part cottonseed meal		35
1 part gluten feed		20
3	3)	70
		23.3 per cent protein.
3 parts wheat bran (3×15)		45
2 parts cottonseed meal (2×35)		70
1 part gluten feed (1×20)		20
6	6)	135
		22.5 per cent protein.

The approximate price of a ration per pound of protein may be ascertained as follows: Divide the total price of the mixture by the average protein content as derived above. The mixture costing the smallest price per pound of protein, other things being equal, is the most economical. Unfortunately, other things are never exactly equal, for the physiological effect of the grain, bulk, and palatability must also be taken into consideration. Practically all the grain feeds low in protein are rich in carbohydrates, but, as already stated, grains are purchased primarily for their protein content, as almost invariably the carbohydrates can be produced more cheaply in the form of corn silage, cornstalks, etc. While the above-mentioned method of testing the economy of a grain ration is not entirely accurate, it is usually a safe method to follow.

Table 6 shows the cost of 100 pounds of digestible protein in some of the common concentrates when they range from $20 to $50 a ton.

By using the table it is possible to compare different feeds as economical sources of protein, although they differ in composition and price per ton. For example, when bran is $25 a ton, 100 pounds of protein costs $10, while in the case of coconut meal selling at $38, the same quantity of protein costs $10.05.

TABLE 6.—*Cost of 100 pounds of digestible protein.*

Price per ton.	Price per 100 pounds.	Barley (ground).	Beet pulp (dried).	Bran (wheat).	Brewers' grains (dried).	Buckwheat middlings.	Coconut meal.	Corn meal or chop.	Corn-and-cob meal.	Cottonseed meal (choice).	Cowpeas.	Distillers' grains (corn, dried).	Distillers' grains (rye).	Gluten feed (high grade).	Gluten meal (high grade).	Hominy feed (high grade).	Linseed meal (O. P.).	Linseed meal (N. P.).	Malt sprouts.	Middlings (wheat).	Oats (ground).	Peanut meal with hulls.	Peanut meal without hulls.	Rye chop.	Sorghum grain.	Soy-bean meal.
$20.00	$1.00	$11.11	$21.74	$8.00	$4.65	$4.07	$5.32	$14.49	$16.39	$2.70	$5.15	$4.46	$7.35	$4.63	$3.31	$14.29	$3.31	$3.15	$4.93	$7.46	$10.64	$4.95	$2.34	$10.87	$13.33	$3.26
21.00	1.05	11.67	22.83	8.40	4.88	4.27	5.59	15.22	17.21	2.84	5.41	4.69	7.72	4.86	3.48	15.00	3.48	3.31	5.17	7.84	11.17	5.20	2.45	11.41	14.00	3.42
22.00	1.10	12.22	23.91	8.80	5.12	4.47	5.85	15.94	18.03	2.97	5.67	4.91	8.09	5.09	3.64	15.71	3.64	3.47	5.42	8.21	11.70	5.45	2.57	11.96	14.67	3.58
23.00	1.15	12.78	25.00	9.20	5.35	4.67	6.12	16.67	18.85	3.11	5.93	5.13	8.46	5.32	3.81	16.43	3.81	3.63	5.67	8.58	12.23	5.69	2.69	12.50	15.33	3.75
24.00	1.20	13.33	26.09	9.60	5.58	4.88	6.38	17.39	19.67	3.24	6.19	5.36	8.82	5.56	3.97	17.14	3.97	3.79	5.91	8.96	12.77	5.94	2.80	13.04	16.00	3.91
25.00	1.25	13.89	27.17	10.00	5.81	5.08	6.65	18.12	20.49	3.38	6.44	5.58	9.19	5.79	4.14	17.86	4.14	3.94	6.16	9.33	13.30	6.19	2.92	13.59	16.67	4.07
26.00	1.30	14.44	28.26	10.40	6.05	5.28	6.91	18.84	21.31	3.51	6.70	5.80	9.56	6.02	4.30	18.57	4.30	4.10	6.40	9.70	13.83	6.44	3.04	14.13	17.33	4.23
27.00	1.35	15.00	29.35	10.80	6.28	5.49	7.18	19.57	22.13	3.65	6.96	6.03	9.93	6.25	4.47	19.29	4.47	4.26	6.65	10.07	14.36	6.68	3.15	14.67	18.00	4.40
28.00	1.40	15.56	30.43	11.20	6.51	5.69	7.45	20.29	22.95	3.73	7.22	6.25	10.29	6.48	4.64	20.00	4.64	4.42	6.90	10.45	14.89	6.93	3.27	15.22	18.67	4.56
29.00	1.45	16.11	31.52	11.60	6.74	5.89	7.71	21.01	23.77	3.92	7.47	6.47	10.66	6.71	4.80	20.71	4.80	4.57	7.14	10.82	15.43	7.18	3.39	15.76	19.33	4.72
30.00	1.50	16.67	32.61	12.00	6.98	6.10	7.98	21.74	24.59	4.05	7.73	6.70	11.03	6.94	4.97	21.43	4.97	4.73	7.39	11.19	15.96	7.43	3.50	16.30	20.00	4.89
31.00	1.55	17.22	33.70	12.40	7.21	6.30	8.24	22.46	25.41	4.19	7.99	6.92	11.40	7.18	5.13	22.14	5.13	4.89	7.64	11.57	16.49	7.67	3.62	16.85	20.67	5.05
32.00	1.60	17.78	34.78	12.80	7.44	6.50	8.51	23.19	26.23	4.32	8.25	7.14	11.76	7.41	5.30	22.86	5.30	5.05	7.88	11.94	17.02	7.92	3.74	17.39	21.33	5.21
33.00	1.65	18.33	35.87	13.20	7.67	6.71	8.78	23.91	27.05	4.46	8.51	7.37	12.13	7.64	5.46	23.57	5.46	5.21	8.13	12.31	17.55	8.17	3.86	17.93	22.00	5.37
34.00	1.70	18.89	36.96	13.60	7.91	6.91	9.02	24.64	27.87	4.59	8.76	7.59	12.50	7.87	5.63	24.29	5.63	5.36	8.37	12.69	18.09	8.42	3.97	18.48	22.67	5.54
35.00	1.75	19.44	38.04	14.00	8.14	7.11	9.27	25.36	28.69	4.73	9.02	7.81	12.87	8.10	5.79	25.00	5.79	5.52	8.62	13.06	18.62	8.66	4.09	19.02	23.33	5.70
36.00	1.80	20.00	39.13	14.40	8.37	7.32	9.54	26.09	29.51	4.86	9.28	8.04	13.24	8.33	5.96	25.71	5.96	5.68	8.87	13.43	19.15	8.91	4.21	19.57	24.00	5.86
37.00	1.85	20.56	40.22	14.80	8.60	7.52	9.79	26.81	30.33	5.00	9.54	8.26	13.60	8.56	6.13	26.43	6.13	5.84	9.11	13.81	19.68	9.16	4.32	20.11	24.67	6.03
38.00	1.90	21.11	41.30	15.20	8.84	7.72	10.05	27.54	31.15	5.14	9.79	8.48	13.97	8.80	6.29	27.14	6.29	5.99	9.36	14.18	20.21	9.41	4.44	20.65	25.33	6.19
39.00	1.95	21.67	42.39	15.60	9.07	7.93	10.31	28.26	31.97	5.27	10.05	8.71	14.34	9.03	6.46	27.86	6.46	6.15	9.61	14.55	20.74	9.65	4.56	21.20	26.00	6.35
40.00	2.00	22.22	43.48	16.00	9.30	8.13	10.57	28.99	32.79	5.41	10.31	8.93	14.71	9.26	6.62	28.57	6.62	6.31	9.85	14.93	21.28	9.90	4.67	21.74	26.67	6.51
41.00	2.05	22.78	44.57	16.40	9.53	8.33	10.82	29.71	33.61	5.54	10.57	9.15	15.07	9.49	6.79	29.29	6.79	6.47	10.10	15.30	21.81	10.15	4.79	22.28	27.33	6.68
42.00	2.10	23.33	45.65	16.80	9.77	8.54	11.08	30.43	34.43	5.68	10.82	9.37	15.44	9.72	6.95	30.00	6.95	6.62	10.34	15.67	22.34	10.40	4.91	22.83	28.00	6.84
43.00	2.15	23.89	46.74	17.20	10.00	8.74	11.34	31.16	35.25	5.81	11.08	9.60	15.81	9.95	7.12	30.71	7.12	6.78	10.59	16.05	22.87	10.64	5.02	23.37	28.67	7.00
44.00	2.20	24.44	47.83	17.60	10.23	8.94	11.60	31.88	36.07	5.95	11.34	9.82	16.18	10.19	7.28	31.43	7.28	6.94	10.84	16.42	23.40	10.89	5.14	23.91	29.33	7.17
45.00	2.25	25.00	48.91	18.00	10.47	9.15	11.86	32.61	36.89	6.08	11.60	10.04	16.54	10.42	7.45	32.14	7.45	7.10	11.08	16.79	23.94	11.14	5.26	24.46	30.00	7.33
46.00	2.30	25.56	50.00	18.40	10.70	9.35	12.11	33.33	37.70	6.22	11.85	10.27	16.91	10.65	7.62	32.86	7.62	7.26	11.33	17.16	24.47	11.39	5.37	25.00	30.67	7.49
47.00	2.35	26.11	51.09	18.80	10.93	9.55	12.37	34.06	38.52	6.35	12.11	10.49	17.28	10.88	7.78	33.57	7.78	7.41	11.58	17.54	25.00	11.63	5.49	25.54	31.33	7.65
48.00	2.40	26.67	52.17	19.20	11.16	9.76	12.63	34.78	39.34	6.49	12.37	10.71	17.65	11.11	7.95	34.29	7.95	7.57	11.82	17.91	25.53	11.88	5.61	26.09	32.00	7.82
49.00	2.45	27.22	53.26	19.60	11.40	9.96	12.89	35.51	40.16	6.62	12.63	10 94	18.01	11.34	8.11	35.00	8.11	7.73	12.07	18.28	26.06	12.13	5.72	26.63	32.67	7.98
50.00	2.50	27.78	54.35	20.00	11.63	10.16	13.14	36.24	40.98	6.76	12.89	11.16	18.38	11.57	8.28	35.71	8.28	7.89	12.32	18.66	26.60	12.38	5.84	27.17	33.33	8.14

SAMPLES OF GRAIN MIXTURES TO BE FED WITH VARIOUS ROUGHAGES.

WITH LOW-PROTEIN ROUGHAGES.

The following grain mixtures are adapted to be fed with roughages of the low-protein class, such as corn silage, corn stover, timothy, prairie, rowen, or millet hays, cottonseed hulls, etc.:

Mixture 1.—Per cent of digestible protein, 18.4:
- 500 pounds corn meal.
- 400 pounds dried distillers' grains (corn).
- 200 pounds gluten feed.
- 300 pounds linseed meal (old process).

Mixture 2.—Per cent of digestible protein, 19.8:
- 100 pounds corn meal.
- 100 pounds cottonseed meal.
- 100 pounds linseed meal (old process).
- 200 pounds wheat bran.

Mixture 3.—Per cent of digestible protein, 19.8:
- 300 pounds corn meal.
- 200 pounds cottonseed meal.
- 100 pounds dried distillers' grains (corn).
- 100 pounds gluten feed.

Mixture 4.—Per cent of digestible protein, 19.8:
- 200 pounds corn-and-cob meal.
- 100 pounds cottonseed meal.
- 100 pounds linseed meal (old process).

Mixture 5.—Per cent of digestible protein, 18.8:
- 200 pounds corn meal.
- 150 pounds cottonseed meal.
- 100 pounds gluten feed.
- 100 pounds wheat bran.

Mixture 6.—Per cent of digestible protein, 18.1:
- 200 pounds corn meal.
- 100 pounds cottonseed meal.
- 100 pounds oats, ground.
- 100 pounds linseed meal (old process).

Mixture 7.—Per cent of digestible protein, 19.4:
- 400 pounds corn meal.
- 200 pounds cottonseed meal.
- 300 pounds gluten feed.
- 400 pounds dried brewers' grains.

Mixture 8.—Per cent of digestible protein, 18.3:
- 200 pounds corn meal.
- 100 pounds linseed meal (old process).
- 150 pounds gluten feed.
- 200 pounds dried brewers' grains.

Mixture 9.—Per cent of digestible protein, 18.4:
- 300 pounds corn-and-cob meal.
- 200 pounds cottonseed meal.

Mixture 10.—Per cent of digestible protein, 19.1:
- 200 pounds corn-and-cob meal.
- 100 pounds cottonseed meal.
- 100 pounds gluten feed.
- 100 pounds buckwheat middlings.

Mixture 11.—Per cent of digestible protein, 19.1:
200 pounds barley.
200 pounds cottonseed meal.
100 pounds alfalfa meal.
100 pounds wheat bran.

WITH HIGH-PROTEIN ROUGHAGES.

With roughage of the high-protein class, such as clover, alfalfa, soy beans, cowpeas, and vetch or other legume hay, the following grain mixtures may be used:

Mixture 12.—Per cent of digestible protein, 14.1:
400 pounds corn meal.
100 pounds cottonseed meal.
100 pounds gluten feed.
100 pounds wheat bran.
Mixture 13.—Per cent of digestible protein, 15.6:
400 pounds corn meal.
200 pounds gluten feed.
200 pounds linseed meal (old process).
100 pounds oats, ground.
Mixture 14.—Per cent of digestible protein, 14.9:
200 pounds corn meal.
200 pounds gluten feed.
100 pounds malt sprouts.
100 pounds wheat bran.
Mixture 15.—Per cent of digestible protein, 16.7:
300 pounds barley.
100 pounds cottonseed meal.
100 pounds alfalfa meal.
100 pounds wheat bran.
Mixture 16.—Per cent of digestible protein, 13.7:
100 pounds barley.
200 pounds coconut meal.
100 pounds oats, ground.
100 pounds wheat bran.
Mixture 17.—Per cent of digestible protein, 15.8:
300 pounds corn-and-cob meal.
200 pounds gluten feed.
100 pounds cottonseed meal.
100 pounds wheat bran.
Mixture 18.—Per cent of digestible protein, 15.5:
100 pounds corn meal.
100 pounds linseed meal (old process).
100 pounds oats, ground.

WITH COMBINATION OF LOW AND HIGH PROTEIN ROUGHAGES.

The following grain mixtures are adapted for feeding with a combination of the low and high protein classes of roughage, such as silage and clover, or other legume hay; corn stover and clover, or other legume hay; mixed hay, or oat-and-pea hay, etc.:

Mixture 19.—Per cent of digestible protein, 16.3:
400 pounds corn meal.
300 pounds dried distillers' grains (corn).
100 pounds gluten feed.
100 pounds linseed meal (old process).

Mixture 20.—Per cent of digestible protein, 16.1:
300 pounds corn meal.
100 pounds cottonseed meal.
100 pounds linseed meal (old process).
200 pounds wheat bran.

Mixture 21.—Per cent of digestible protein, 16.4:
400 pounds corn meal.
100 pounds cottonseed meal.
200 pounds dried distillers' grains (corn).
100 pounds gluten feed.

Mixture 22.—Per cent of digestible protein, 16.7:
400 pounds corn meal.
100 pounds cottonseed meal.
200 pounds gluten feed.
200 pounds dried brewers' grains.

Mixture 23.—Per cent of digestible protein, 16.4:
200 pounds corn-and-cob meal.
100 pounds cottonseed meal.

Mixture 24.—Per cent of digestible protein, 16.7:
200 pounds corn meal.
100 pounds peanut meal (with hulls).
100 pounds cottonseed meal.
100 pounds wheat bran.

Mixture 25.—Per cent of digestible protein, 16.4:
100 pounds corn meal.
100 pounds oats, ground.
100 pounds cottonseed meal.
100 pounds wheat bran.

The above-named mixtures which contain linseed meal are particularly adapted for use when no succulence is in the ration.

QUANTITIES OF ROUGHAGE AND GRAIN TO FEED.

In this connection the general principles brought out earlier in the discussion should always be kept in mind, namely, that economical feeding demands that the cows be fed to full capacity. To do this and to have the best effect on the individual cow requires a thorough knowledge of feeds and of cows. To give a few practical rules to guide the beginner in obtaining this knowledge is all that has been attempted in this publication. Rules of this nature in reference to the quantities to feed will not be out of place.

1. *Under most circumstances the cow should be fed all the roughage that she will eat up clean, adjusting the grain ration to the milk production. Only when the cow tends to become overfat should the quantity of roughage be restricted.*

2. *A grain mixture should be fed in the proportion of 1 pound to each 3 pints or pounds of milk produced daily by the cow, except in*

the case of a cow producing a flow of 40 pounds or more, when the ration can be 1 pound to each 3½ or 4 pounds of milk. An even better rule is 1 pound of grain each day for every pound of butter fat produced during the week by the cow.

3. *Feed all the cow will respond to in milk production. When she begins to put on flesh, cut down the grain.*

INDIVIDUAL FEEDING.

Different cows have different capacities for converting feed into milk. For this reason the above-mentioned rules can serve only as indicators for the inexperienced feeder. No man who has not a full appreciation of the wide variation in individual cows will be fully

FIG. 1.—Weighing out the right quantity of grain for each cow.

successful as a feeder. Some cows may have natural capacity for producing large quantities of milk, and may not receive feed enough for maximum production. By increasing the feed of the highest-producing cows and carefully consulting the milk sheets on which each cow's daily production is recorded, the skillful feeder will soon find that some cows in the herd will respond to the increased allowance and return a good profit on the additional feed given. On the other hand, there are cows that have a limited capacity for milk production and are very liable to be overfed. By carefully studying each individual cow the feeder will soon ascertain the point beyond which any addition to the grain ration becomes unprofitable.

WATER FOR COWS.

All animals require plenty of good, pure water. This is especially true of the milking cow, as water constitutes more than three-fourths of the total volume of milk. The water supply, therefore, demands the dairyman's most careful attention. Stale or impure water is distasteful to the cow and she will not drink enough for maximum milk production. Such water may also carry disease germs which might make the milk unsafe for human consumption or be dangerous to the cow herself. During the winter, when cows are stabled the greater part of the time, they should be watered two or three times a day unless arrangements have been made to keep water before them at all times. The water should, if possible, be 15° or 20° above the freezing point, and should be supplied at practically the same tem-

FIG. 2.—Pasture is the natural feed for dairy cows.

perature every day. When water well above freezing temperature is stored in tanks and piped directly to the cow, there is probably little occasion for facilities to warm it. When it stands in a tank on which ice often forms, it usually pays well to warm it slightly. This can be done by a tank heater, by live steam, or by hot water from a boiler. If a boiler is used for running a separator or for heating water to wash and sterilize utensils, steam from it can readily and cheaply be used to warm the water.

SALT.

Salt is required by all animals. The dairy cow requires an ounce or more a day, and while she should be given all she needs, she should not be forced to take more than she wants. It is best, therefore, to give only a small quantity on the feed, and to place rock salt in boxes in the yard where she can lick it at will.

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